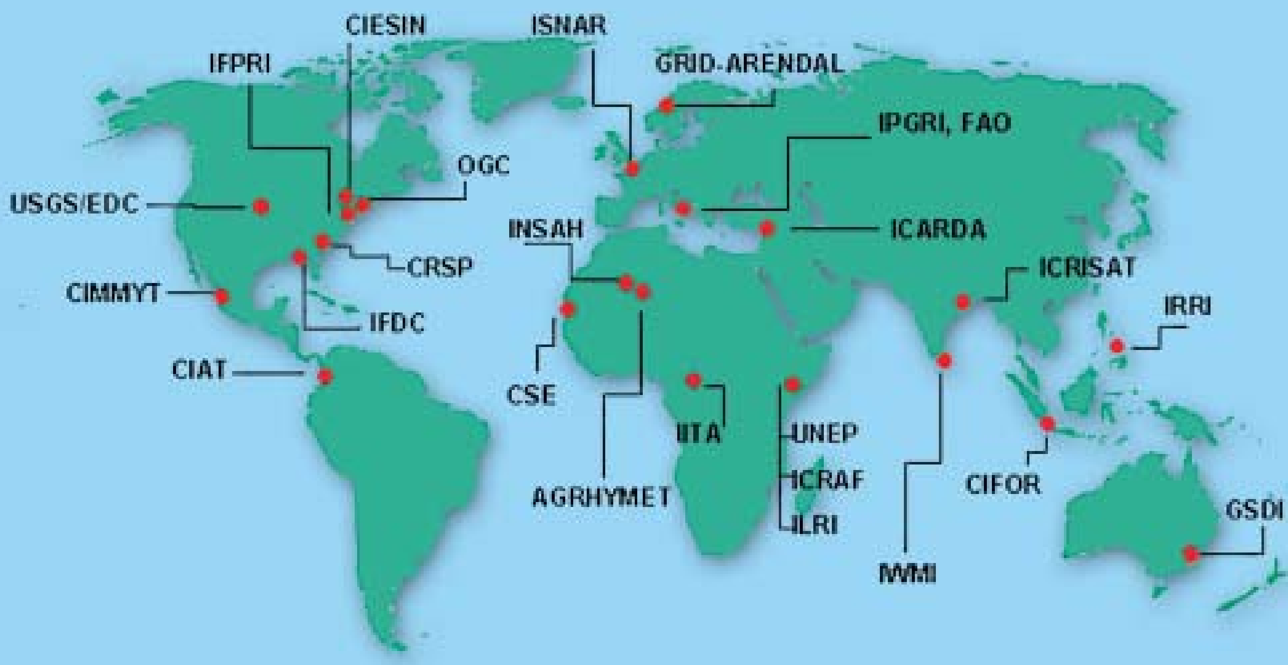

Geospatial Applications to Support Sustainable International Agriculture

GASSIA Workshop Report

U.S. Geological Survey/EROS Data Center

Sioux Falls, South Dakota, USA

May 19-31, 2002

GASSIA is a collaborative effort of the Consortium for Spatial Information (CSI) of the Consultative Group on International Agricultural Research (CGIAR), the USGS/EDC, the Collaborative Research Support Program (CRSP) and other organizations applying remotely sensed and geospatial data and promoting sustainable international agriculture

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This Workshop Report summarizes the highlights of the meeting. The complete workshop, including agenda, participants, resource papers, and presentations is available on the accompanying CD and on-line at http://edcintl.cr.usgs.gov/cgiar/pres.html

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APPENDICES

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ACRONYM LIST

ADDS	Africa Data Dissemination Service
AEGIS	Agricultural and Environmental Geospatial Information System
AGIS	Agricultural Geographic Information System
AGRHYMET	Regional Agricultural-Hydrological-Meteorological Center
APIB	Agro-climatic Planning and Information Bank
ARC	Agricultural Research Council
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIESIN	Center for International Earth Science Information Network
CIFOR	Center for International Forestry Research
CILSS	Permanent Interstate Committee on Drought Control in the Sahel
CIMMYT	International Maize and Wheat Improvement Center
CRSP	Collaborative Research Support Program
CSE	Centre de Suivi Ecologique
CSI	Consortium for Spatial Information
DMS	distributed map server
DSAAT	Decision Support System for Agrotechnology Transfer
DSS	Decision Support System
EDC	EROS Data Center
EIS	Environmental Information Systems
EROS	Earth Resources Observing System
ESRI	Environmental Systems Research Institute
ESSE	Earth System Science Education
FAO	Food and Agriculture Organization
FEWS	Famine Early Warning Systems
FEWS NET	Famine Early Warning Systems Network
FUD	fear, uncertainty, doubt
GASSIA	Geospatial Applications to Support Sustainable International Agriculture
GIS	Geographic Information Systems
GIST	Geographic Information Support Team
GPS	Global Positioning Systems
GRID	Global Resource Information Database
GSDI	Global Spatial Data Infrastructure
HIU	Humanitarian Information Unit of U.S. Department of State
IARC	International Agricultural Research Center
ICARDA	International Center for Agricultural Research in the Dry Areas
ICASA	International Consortium for Agricultural Systems Applications
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	information and communication technologies
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
IMS	Internet Map Server
INSAH	L' Institut du Sahel
INSPIRE	INfrastructure for SPatial InfoRmation in Europe
INTSORMIL	International Sorghum and Millet
IPR	Intellectual Property Rights
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
ISO	International Standards Organization
ISRO	Indian Space Research Organisation
IT	Information Technology
IWMI	International Water Management Institute
MAG	Ministry of Agriculture
NARC	National Association of Regional Councils
NARS	National Agricultural Research System
NDA	National Department of Agriculture
NED	National Elevation Data
NGO	Non-government organization
NOAA	National Oceanic and Atmospheric Administration
NSDI	national spatial data infrastructures
OGC	Open GIS Consortium
PDA	personal data assistant
PDA	Provincial Departments of Agriculture
RS	remote sensing
SANREM	Sustainable Agriculture & Natural Resource Management
SCAA	Specialty Coffee Association of America
SDI	Spatial Data Infrastructure
TRFIC	Tropical Rain Forest Information Center
UNEP	United Nations Environment Programme
UNGIST	United Nations Geographic Information Support Team
UNGIWG	United Nations Geographic Information Working Group
USAID	U. S. Agency for International Development
USGS	U.S. Geological Survey
USRA	University Space Research Association
WSSD	World Summit on Sustainable Development

Geospatial Applications to Support Sustainable International Agriculture

Executive Summary

The increasing importance of accurate and accessible geospatial data for a wide range of sustainable development activities has become increasingly clear to the research and development organizations as they collaborate in agricultural, disaster, early warning, conservation, and economic development activities in developing countries. In response to the need for improved geographic information for development, the GASSIA Workshop assembled more than 65 geographic information science and technology professionals from 28 international and regional organizations (Cover, Appendix A). This diverse group from international research centers, Africa regional centers, European organizations, U.S. organizations and agencies, private companies, and public groups represented an equally broad range of disciplines. They discussed what each could do to provide more effective and flexible data sharing, exchange, and dissemination as well as how they all might cooperate to formulate a global alliance to strengthen spatial data infrastructures, foster joint project implementation, and support sustainable development. They attended the 2-week workshop held at the USGS/EDC in Sioux Falls, South Dakota; initiated some immediate actions; and defined a series of recommendations.

Participants from the first week on technical components agreed to **undertake an immediate implementation of a distributed network of clearinghouses and interoperable servers for spatial data access and delivery**. The EDC agreed to provide additional technical support as the participants undertook a cooperative multiviewer presentation of these shared resources for an on-line presentation at the WSSD. Most participants left with ArcIMS and other necessary software and instructions for the installation of operational web map and data servers.

The solution proposed by the workshop participants during week 2 is a “framework” or “infrastructure” consisting of core datasets, data standards, data policies, and demand-driven tools. In effect, these will help establish a functional information “backbone” for the research and development communities with special relevance to agriculture. The specialists also called for an “overhaul” to the way projects using geospatial data are designed. At the onset, data standards must be incorporated into the project work plan, the relationships between data producers and data users (researchers and clients) must be clearly articulated, and provisions to include project results, data, and metadata in accessible and searchable forms must be specified.

In addition to the immediate implementation, recommendations were made in **four** other areas. **First, recommendations on core data set assessments, development, and standards** were emphasized and a working group was established to facilitate the attainment of the Agricultural and Environmental Geospatial Information System (**AEGIS)** concept**. Secondly, workshop participants recommended that capacity building be given high priority**. A working group was formulated to develop a requirements analysis for a distributed global information network to be discussed with potential donors. **Third, a framework for future collaboration was developed** to maintain the human resources network established at GASSIA and to propose a continuation workshop organized by a working group which will also present recommendations to Center and Organization directors. **Finally, recommendations for donors were formulated** and included greater acceptance of best practices with respect to data development, documentation, and distribution, including a requirement that commitments for data development and distribution become a part of project awards.

The GASSIA workshop can be viewed as a catalyst for a strategic alliance of the CGIAR, the EDC, the CRSPs, UNEP, FAO and other regional and national research and development centers working in geographic information science for sustainable agriculture.

Introduction and Background

The GASSIA Workshop is a major response to the increased need, especially in developing countries, for ready access to spatial data in support of agricultural development and sustainability, natural resource and environmental management, climate mitigation, and economic development.

The workshop was also undertaken in response to a recent and powerful convergence of technological advances that facilitate greater opportunities for cooperation and facilitated work among scientists and development projects around the world. Advances in information and communication technologies and geographic information science are having significant impacts on research and development in global agriculture and sustainable development. Farmers, agricultural engineers, extension agents, development experts, commodity brokers, and others are increasingly integrating GIS, GPS for georeferencing, and remote sensing (RS) technologies together with ICT to support economic growth and help alleviate poverty and attain sustainability. This technological integration supports precision agriculture, assessments of the impacts of local development projects, planning farm management decisions based on weather analyses and forecasts, the identification of areas vulnerable to natural and man-made hazards, the selection of site specific areas for climate mitigation projects, the matching of crop varieties to environments for improved seed selection, monitoring for early warning and desertification, and the certification and on-line sale of specialty coffees, as examples. Although much of this innovation occurs in the more developed countries and in the private sector, the opportunities for complementary interactions and positive feedback with counterparts in developing countries are great and need to be nurtured. The implications of these new developments for developing-country agriculture, resource management, environment protection and economic growth are also great and were identified in the 1998 “Strong Report,” entitled “Shaping the CGIAR’s Future.”

> “*New communication and computing technologies will have profound implications in everyday research activities. Access to the Internet will soon be universal, and this can provide un-restricted low-cost access to information as well as highly interactive distance learning and other benefits. The Internet will not only facilitate relations among all researchers, it will also greatly improve their ability to communicate effectively with the potential users of their research knowledge. Computing also allows the processing of large-capacity databases (libraries, remote sensing and GIS data, gene banks) and the construction of simulation models with possible applications in ecosystem modeling and economics.*”

The workshop and its recommendations are also in direct support of the World Summit on Sustainable Development (WSSD) with its emphasis on Agenda 21. The EIS-Africa Position Paper and the African Ministerial Statement (Nairobi, October 18, 2001) endorse the promotion of geoinformation and new technologies for sustainable development. Furthermore, they and this workshop identify the following important elements of an effective SDI for sustainable development:

- the existence of core geo-data sets;
- the accessibility of documentation about existing geoinformation;
- the adherence of geoinformation to accepted standards;
- policies and practices promoting the exchange and reuse of information; and
- sufficient human and technical resources to collect, manipulate, and distribute geoinformation.

The GASSIA Workshop Components

More than 65 geographic information science and technology professionals from 28 international and regional organizations (Cover, Appendix A) participated to discuss what they could do to provide more effective and flexible data sharing, exchange and dissemination as well as cooperate on project development and implementation. Although the initial proposal (http://edcintl.cr.usgs.gov/cgiar/proposal.html) outlined objectives for the CSI and the EDC, it soon became apparent that the workshop was an opportunity to include a wider group of organizations active in international agriculture and related geospatial data and sustainable development activities. Thus, organizations representing regional centers in Africa, e.g., AGRHYMET and CSE; CRSP; the private sector, OGC, Mud Springs Geographers, Inc. and SCAA, and international programs, e.g., UNEP/GRID and FAO also participated. The core objectives, described in detail in the original proposal, were maintained with slight modifications:

- Secure a committed group of participants
- Identify specific data inventories
- Enhance the organizational structure to facilitate continued cooperation
- Develop plans for further development of spatial data infrastructures and clearinghouses
- Conduct training in appropriate metadata development using modern metadata tools
- Assist in the establishment of functional nodes
- Establish a minimum set of metadata to be completed
- Develop capabilities for interactive Internet Map Serving
- Secure software and implement ArcIMS and appropriate Database systems

The GASSIA Workshop focused on education and capacity-building in recent technological approaches and applications, spatial data infrastructures, IPR in the context of GIS, and planning for future development of geographic information science and technology in developing world applications.

Week 1: The first week concentrated on technical training, evaluations of approaches to data distribution, availability of on-line analytical tools and other analytical and decision support systems, and detailed sharing of project applications. Formal training included:

- Participants (27) mastered the elements of IMS technologies with certified training by ESRI instructors and other users.
- The course included training in how to create web pages for serving maps, how to use Java and XML programming languages for developing customized applications, and how to make a web site OGC-compliant.
- Additional map server approaches, were presented, implemented, and compared with ArcIMS.
- The mechanism for the distribution of ArcGIS and its installation at each relevant site were established.
- Geographic metadata standards including ISO standards were presented.
- Software to enable and facilitate metadata production was provided.
- Software and installation information for data clearinghouse Internet nodes, Isite, were provided and tested.

The training was enriched by numerous presentations of live applications, discussions of approaches to the development and use of spatial data tools, and evaluations of approaches to data sharing and applications:

- Applications of IMS for Sustainable Tree crops - Coffee, Cocoa, and Bananas
- Country Almanac and Data Warehouse
- FEWS NET: Operational overview of data resources and distribution (ADDS)

- Geographic Information for Research and Development at CIAT
- Using ArcIMS to present NED and References
- Rainfall Estimation and Spatially Explicit Crop Modeling in support of FEWS NET
- Internet Delivery of GIS Data
- Real time hydrologic applications and stream flow modeling for disaster prevention in Africa and Southeast Asia
- UNGIWG Multiserver demonstration

Week 2: The second week emphasized non-technical organizational aspects of improving ICT for enhanced data access and distribution, GIS and RS applications, and the development and application of spatial data tools for sustainable development activities. Technical representation from the first week was supplemented by additional participants representing management and administrative positions within the organizations.

Keynote Speaker: United Nations Global Ambassador for Hunger, George McGovern, focused the goals of all workshop participants with a compelling presentation on “Hunger alleviation, food security, and global poverty.” He encouraged Workshop participants by saying, “It’s going to take all the scientific know-how we have to increase productivity on land already under cultivation to feed the world in the next 50 years, and I think we can do it with the type of work that you are doing.” His participation in the GASSIA Workshop was solicited in response to his long record of active humanitarian support, his past leadership role as Ambassador to the FAO, and his insight into the complexities of global hunger, poverty, and development.

Special Event 1: A one-day IPR seminar, organized by the CGIAR Central Advisory Service on Intellectual Property introduced participants to a wide range of concerns related to legal and practical issues in the creation and use of spatial data (Appendix C). “IP refers to the rights granted by law in relation to the fruits of human creative activity. In the context of this policy, it includes copyrights, all rights in relation to inventions, registered and unregistered trademarks, registered designs, and all other rights resulting from intellectual activity in the industrial, scientific, literary or artistic fields” (http://www.v-cafe.org/dltest/Legal_Issues_Guide_15Apr02.pdf). A draft of the detailed and informative document, “Legal Issues in Use of Agricultural and Environmental Geospatial Data and Tools,” is available on-line and will be published in final form soon.

Many of the GASSIA participants were new to IPR issues and options. Spatial data development for international agriculture will require greater emphasis on resolving IPR issues, and clarifying policies governing data ownership. Policy and legal considerations related to geographic information resources are similar to those dealing with biological resources in agriculture. Strategies for managing intellectual property rights issues will be formed in the context of the working paper following discussions at GASSIA on this topic.

Special Event 2: The **AEGIS** (http://edcsintl.cr.usgs.gov/cgiar/AEGIS-1.pdf) was presented as a framework around which planning for future cooperative activities could be undertaken. AEGIS can be a vehicle to facilitate the work and interests of international organizations and projects, stimulate and support data sharing and distribution, and provide resources to promote sustainable agriculture and alleviate poverty. This “GIS Backbone” vision will be attained by building on the diverse strengths of many partners, yet provide for the creation of an integrated and seamless access system to data and knowledge via the Internet. The “GIS Backbone” must be seen as a long-term vision that will take 10 to 15 years to achieve - not a specific project. The design of an achievable AEGIS system could provide a mechanism for supporting field units and collaborating partners with additional **resources, training, institutional support,** and **tools** to address the following objectives:

- Measure progress more effectively regarding decisions and investments made by the donor agencies that affect policies and practices in agriculture and natural resource management.
- Improve global monitoring, assessment and tracking systems that can certify and verify the impact of agricultural and land management investments made by donors.

- Provide information/data on appropriate “best practices” for adaptation to climate variability and other natural or human-induced vulnerabilities affecting agroecosystems, to rehabilitate degraded lands, foster environmental management and mitigate climate change.
- Improve market access and business opportunities for the rural poor while enhancing better natural resource management, i.e. promote “win-win” approaches to sustainable development, e.g. through promotion, certification and verification of value-added agricultural production systems that increase trade competitiveness and reduce poverty.
- Increase transparency and accountability to the public at large as well as institutional systems, in ways that reduces conflict and promotes good governance while reducing poverty and promoting food security.
- Respond to customer demands for food safety and other threats to food quality.
- Foster science-based agriculture that is environmentally, socially, and economically sustainable.

In addition, the AEGIS document identified the following issues which formed the basis for further presentations and discussions as planning continued:

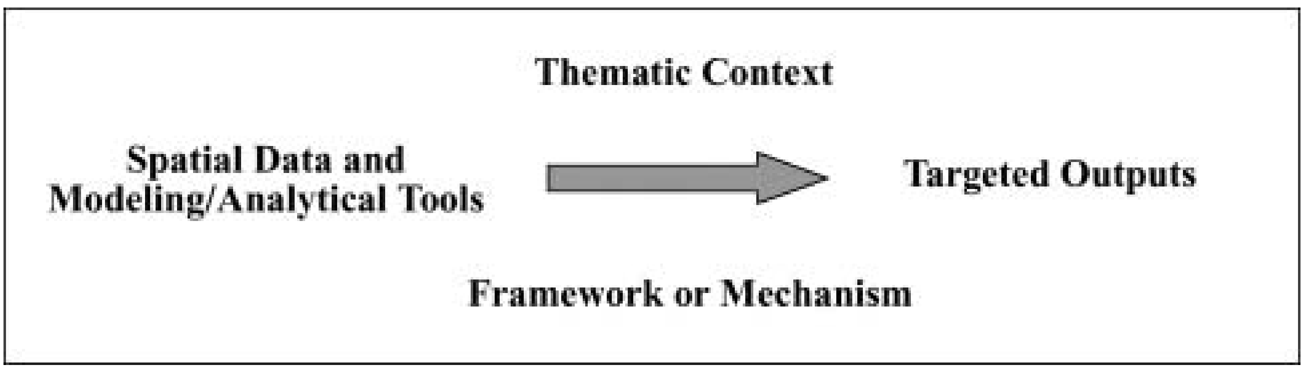
- **IPR** issues for all organizations. How can we still maximize access to data while recognizing legitimate “property and privacy” issues?
- What types of **platforms/standard software** are needed for “portals/clearinghouses” so data sharing and on-line analyses are facilitated?
- **Training/capacity-building issues and problems** need attention at all scales – global, regional, local and at varying institutions. How can this be facilitated?
- What should be the approach toward **defining and developing/sharing “tools” such as desktop GIS viewers, classification tools, modeling tools**, etc.
- What can be done to better **create tools that follow standards that are interoperable, etc**?
- How should we decide on the **appropriate balance of private, i.e., proprietary tool development and public support** for the public good? How do we ensure reliability, updating, standardization, etc?
- What type of **“network building-organizational structure”** is needed to ensure maximum collaboration without being too bureaucratic? What kind of institutional structure can maximize collaboration?
- How do we maximize sharing, **interchange between technology developers & IT companies in private sector while at same time meet “public good” needs and requirements**?
- How do we broaden cooperation on **SDI issues** among diverse participants and countries?
- What are the most important **spatial datasets that are needed for sustainable development** and who needs to work on creating, updating, and maintaining them? How can we make them sustainable financially?
- How do we **maximize participation by developing nations and institutions**?
- How do we meet **special user needs**, e.g. livestock, carbon sequestration and climate adaptation, water/land management, agricultural biosafety and biodiversity, agribusiness and market linkages, sustainable livelihoods and poverty reduction?

Following a description of AEGIS, several presentations (http://edcintl.cr.usgs.gov/cgiar/pres.html) described the importance of this approach for the development of agriculture and capacity building in the area of spatial data delivery, applications, and development. The applications were exemplified for agricultural monitoring by the FEWS program, and required data for disaster preparedness and responses were identified. Private and public sector approaches to data access and distribution were described, especially as they allowed collaboration and Internet access from distributed systems of data servers. Specific needs in Africa were reviewed and placed in the context of a growing global awareness of the importance of spatial data infrastructures as the progress and future plans of the GSDI were presented. The importance of understanding both the location of vulnerable populations and especially the causes of impoverishment and food insecurity were highlighted by the poverty and vulnerability mapping work of several CGIAR centers and World Bank projects. All participants then presented 68 posters illustrating relevant work in these areas. This provided an excellent opportunity to understand the work at the various organizations as well as to form alliances for future collaboration in specific project activities and to share commonly needed spatial data.

These presentations were then used to form the basis of further discussions and planning. These detailed planning sessions were preceded by specific responses from a variety of sectors and interest areas. These included discussions of the role of private sector involvement in the development of both tools and spatial data as well as the necessity for both CD-based information and tools and internet based support systems. Input and perspectives were provided by several international efforts to provide information delivery of both socioeconomic and biophysical types and also UNEP's program to provide synthesized information for decision makers and policy formulation. This was then highlighted by a discussion of the future role and growing opportunities provided by current and new satellite based sensors and an evaluation of the processing and archive facilities of the EDC.

Initial breakout sessions defined the priority topical areas that needed to be discussed and addressed to meet the implementation of an AEGIS-like program and to facilitate the cooperation of the various organizations within the context of their individual mandates. A steering committee synthesized the output from the breakout sessions and conceptualized the diverse suggestions into the following framework and defined five breakout groups to address needs, consider strategic approaches, and formulate recommended actions.

A simple framework for the development of an "Agricultural and Environmental Geospatial Information System" (AEGIS):



<u>Thematic Context</u>

It was recognized that there are sets of data, core data in this sense, that are necessary for all thematic topics and that each theme would also likely require data sets that might be uniquely required in that area. Thus some data sets should be considered core and of widespread utility, but all data sets should be considered generally useful for other themes or projects.

<u>Spatial Data and Modeling/Analytical Tools</u>

It is necessary to define the core data needs in developing countries, to determine appropriate standards to be implemented for geospatial data, to evaluate data development and data distribution difficulties, and to conduct a needs assessment with developing countries.

<u>Targeted Outputs</u>

What are the requirements for applications that are highest priority and what other needs should be met both for international organizations, NARS, and at various political levels within each country? In addition to applications and data development, what capacity building is needed, what infrastructure support is required, and how can peer spatial scientists be more effectively linked across sectors and internationally?

<u>Framework or Mechanism</u>

What are the means by which the above can be achieved? What actions can be taken now, what actions can be phased in time, and what recommendations to various organizations - Centers, NARS, CRSPs, donors, etc. can be made? How can the momentum gained by GASSIA for an AEGIS be maintained and supported?

There are several key elements or assumptions in the framework or infrastructure illustrated above. The system can now consist of a backbone with distributed servers or nodes and innumerable access points from both powerful super computing facilities and inexpensive desktop computers with simple browser capabilities. Multiple "gateways" or "portals" to remotely sensed imagery, geo-referenced censuses, national core data, distributed climatology and weather forecasts, related agricultural information, etc. will exist. The gateways will facilitate resource discovery, access, and delivery, but still will allow custodians to retain control over their data and tools. The technology and standards exist to make this an operational reality. What may not yet exist is the commitment to interoperability among all potential participants and the widespread availability of broad and inexpensive bandwidth in developing countries. Better mechanisms still need to be implemented to transfer these data and tools to partners in developing countries; and better feedback mechanisms to gauge impacts are also required. These data sets and tools will be accessible to a much wider audience thereby better supporting improved decision-making.

GIS for Developing Country Agriculture

New developments in geographic information science and technology are changing the way we apply GIS to developing-world agriculture, creating new opportunities to utilize the technology to address problems of poverty and food security, disaster management, climate change, land use change, land degradation, crop analysis and impact assessment. Today, the adoption of common data standards and map services on the Internet is transforming the way we make use of spatial data. Accepted standards for data documentation and data quality improve the possibility for future use of geographic information. The number of GIS users is expanding because developers can now produce custom applications on the Internet that anyone can use. A great deal of progress has already been made in bringing GIS to developing world agriculture. Some well-known examples include:

- The FEWS NET regularly provides tri-monthly remote sensing estimates of vegetation condition and rainfall occurrence to hundreds of decision-makers throughout Africa and elsewhere (http://www.fews.net). The estimates are used with information collected on the ground to develop actions mitigating food security problems before they become severe. FEWS NET scientists used these monitoring tools to support the spring wheat seed distribution in Afghanistan earlier this year. Geographic information technology was also used to create a spatial crop water balance for mapping the extent of the 2002 drought in Southern Africa. These results were used to help Crop and Food Supply Assessment Teams in Zimbabwe, Zambia, Malawi, and Mozambique select sites for field visits in May, 2002.

- Agricultural scientists used GIS technology in "Seeds of Hope" projects to match sought-after food crop seeds to appropriate environments for hundreds of thousands of farmers whose operations were displaced by political conflict and natural disasters in Africa and Central America. For example, relief workers used GIS to design a program to geographically distribute 200 tons of bean seeds to survivors of the 1994 Rwandan civil war. Matching seed varieties to the best-suited local environments was a key element of this crash program to restore food production following the civil war.

- Agricultural and demographic atlases were a vital tool for in targeting relief efforts in rural areas of Central America following the devastating Hurricane Mitch in 1998. Andrew Pinney, the coordinator of the Central American Red Cross program for agricultural regeneration said, "I had very specific questions, and the atlas provided answers." The planning meeting in San Salvador immediately following the hurricane also concluded that consistent trans-boundary data were essential for planning and responding and an information system providing access to compatible data was needed.

- A remote sensing- and GIS-based agroecosystems assessment made available new global estimates of land in cultivation, effects of land degradation on agricultural ecosystems, and soil fertility declines. The study quantified for the first time the main threats to agricultural ecosystems in the coming decade. Studies such as this one can help the international community set priorities for future research and development in the agricultural sector (http://www.ifpri.org/media/innews/2000/052200b.htm).

- The Umlindi Web site (http://www.esri.com/news/arcuser/0402/umlindi.html) helps farmers and government decision makers in the Republic of South Africa assess current drought conditions, fire risk, and vegetation growth, and compare current conditions to historical norms using GIS-produced maps. Visitors to the site can query the available data on crop growth and drought, vegetation activity, rainfall, and fire. The Government of South Africa's NDA realized that GIS, with its capability for storing, analyzing, and integrating data, was the only viable option for addressing issues associated with population growth while complying with international agreements such as Agenda 21. The AGIS is a joint venture of the NDA, the ARC, and the PDA. The Web applications, such as Umlindi, make data already available more readily accessible. The ARC-Institute for Soil, Climate, and Water, using financial aid from NDA, implemented Umlindi. This application uses information derived from NOAA satellite and climate data that is processed and displayed using ArcView 3.2 with the ArcView Spatial Analyst extension to produce the fire, rainfall, natural vegetation, crop growth, and drought maps. Four query categories are available – crop growth and drought, vegetation activity, rainfall, and fire. Mapping these indicators using GIS helps government decision makers and farmers monitor the conditions that affect crop productivity. A better understanding of conditions on an ongoing basis helps planning efforts and, by providing an early warning system, aids in response to adverse conditions such as the outset of a drought.

- The CGIAR centers, FAO and UNEP began implementation of a food security mapping initiative this year. CGIAR centers will conduct 8 national-level case studies that will employ spatial analysis in the study of food security and poverty problems (www.povertymap.net).

- The ISRO and the Planning Commission are setting up an APIB as a sustainable development strategy to bring about structural changes in agricultural data and information. The information from ISRO's Regional Remote Sensing Service Centre, Bangalore is stored digitally and the content is made available to farmers on the Karnataka Agricultural Department Web site. The bank offers information on crop varieties, marketing, fertilizers, cost of cultivation, area under cultivation, dairying, and insurance (http://www.gisdevelopment.net/news/2001/jun/news260601.htm).

- The TRFIC begins to approach true Web-based GIS by allowing users to upload their shape files and do their digitizing on screen. The user can add his or her own geometry to the Web-based GIS, whether prebuilt in files, or constructed on-the-fly in a browser, using the tools provided by the site. TRFIC also approaches a truly distributed application with a database server at the Jet Propulsion Laboratory. Furthermore, one can pull in data layers from different parts of the world, and apply it to one's map on a desktop (http://www.bsrsi.msu.edu/trfic/).

While the examples listed above show some of the potential for geospatial applications for sustainable agriculture, these are only the beginning of what is possible if we can integrate disciplines, data, technology and ICT. The adoption of common data standards and map services on the Internet is transforming the way we make use of spatial data. Accepted standards for data documentation and data quality improve the possibility for future use of geographic information. The number of GIS users is expanding because developers can now produce custom applications on the Internet that anyone can use. The next section describes the work of GASSIA Workshop participants to develop working papers and strategies aimed at the goal of integration.

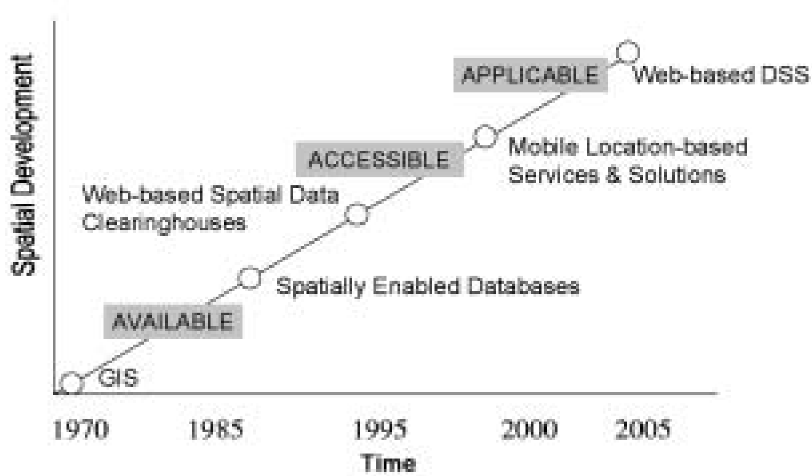
New Approaches for Integration and Development

Participants had access to a number of resource papers (http://edcintl.cr.usgs.gov/cgiar/RP.html) and an on-line discussion (http://www.v-cafe.org/) prior to the meeting. The general background presented in some of these and related references, however, will be reviewed briefly here.

Research increasingly is a team endeavor, combining scientists of different disciplines, not necessarily in the same location, and combining data stored in disparate archives and databases. A CIAT sociologist, an ICRAF soil scientist, an AGRHYMET hydrologist, and a USGS remote sensing specialist together might be studying crop varieties and soil erosion in the Sahel. New geospatial and information technologies allow scientist to move from the field to office, farm to watershed, or the local to global scale. Researchers are now using mobile spatial data logging units composed of a GPS linked to a PDA running ArcPad™ so that they can enter geo-referenced survey data that are immediately GIS-compatible. Farmers in Mali receive satellite updates about impending storms on hand-wound radios. New animation software such as Macromedia Flash provides a more dynamic environment with which to interact on the web. These web-based perhaps cannot be used by farmers right now, but they do show the possibilities of coupling GIS with other IT tools for facilitating data capture on the one hand, and for providing more effective delivery of GIS products on the other. It is also clear that the technological advances will not only facilitate the technical scientists, it will also result in economic benefit to the rural poor and small holder. The integration now allows a buyer to verify the certification practices of individual farmers in Dominica from the bar code on a set of bananas purchased in England (http://www.dbmc-dm.com/ and http://edciintl.cr.usgs.gov/carlises.html) or the availability of certain coffee grown at specified altitudes in Peru (http://www.perucoffee.com/). And, recently a system developed in Kenya actually conducted a cupping competition and sold coffee on-line at a substantial premium (http://africanlion.com).

When it comes to GIS, remote sensing, simulation models, Internet mapping, and digital data exchange there are new standards and new data policy and legal issues that demand the agricultural and development community's attention. The framework proposed by AEGIS is not merely a pro-GIS initiative. It is a new paradigm for global development because it is about building alliances to achieve efficiency, sharing of information, appropriate intellectual property regulations, and responsiveness to new technologies that are being introduced. GIS used to be a 'stand alone' tool, often in the control of select technical experts but since the new millennium, we are seeing the power of networks and interoperability across the Internet. Several noteworthy examples of state-of-the-art implementations are described in Appendix B. The most cutting-edge area of research now is with web-based decision support systems (Figure 1).

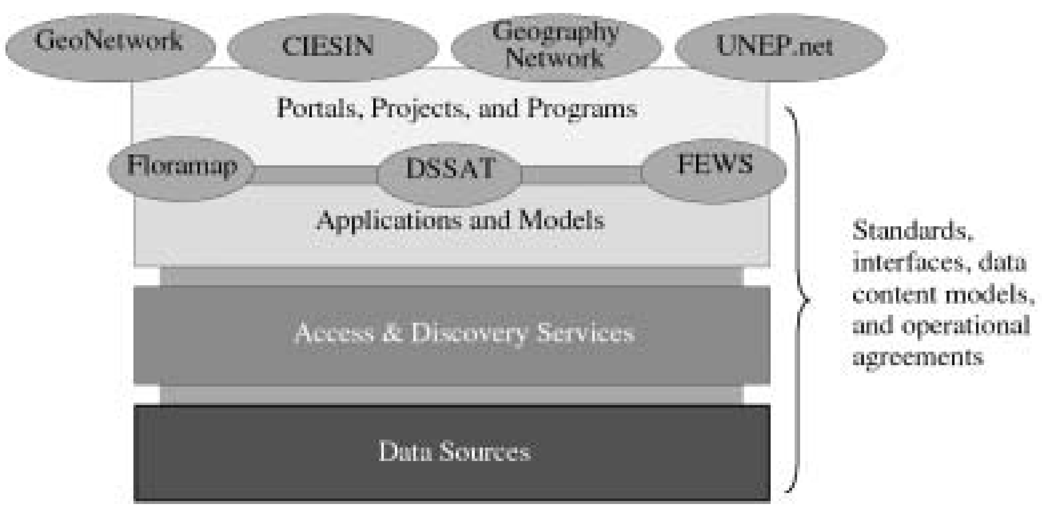
Figure 1. A trend in automated cartography (Kelmelis, 2001)



Technology is changing rapidly. GIS specialists, research administrators, and development experts are eager to take advantage of these changes because they dramatically increase data exchange and data compatibility and result in very real economic advantages. At the same time, the research community is feeling the weight of intellectual property issues. On several occasions, CIMMYT's Mexican institution partners have required CIMMYT to sign a Memorandum of Understanding before the institutions would provide their data. CIMMYT is now distributing a material transfer agreement with some electronic data sets, although this is a not a center-wide policy. Numerous other cases of data restrictions and or inordinate costs for data use could be cited. It is clear that a better understanding of the role and management of intellectual property - be it data or software - needs urgent attention at this time in order to keep pace with the digital / technological advances. In a manner very similar to crop breeding and biotechnological developments, sources that used to be free or readily shared between partners, now come with strings attached.

With respect to geospatial technologies, the time has come to develop a single interoperable infrastructure, so that data, software, models, tools, and the Internet can be used seamlessly. If coordinated planning and agreement on appropriate base maps do not take place now, problems in integrating data are likely to continue. For instance, without coordination, coincident line problems arise when two geographic layers are overlaid and lines such as shorelines, rivers, and administrative divisions do not line up when in fact they are supposed to be spatially congruent. The non-coincident lines are a significant data processing/integration problem. It is essential that a national boundary is also a district boundary or that a district boundary that borders a river coincides with a river layer. Unfortunately, throughout the world, different versions of core data layers are in circulation from various agencies, since many users have digitized their own layers. This plethora of different versions of datasets from different sources ultimately results in many lost person hours, and this translates into wasted financial resources. Consistent base layers need to be established so that they serve as a standard for GIS use for a country, and serve as building blocks for regional datasets.

Figure 2: Diagram of data infrastructure components.



The overall data infrastructure, shown in Figure 2, has consistent core data sets at the base level. Embedded in the 'data sources' layer are data standards that govern how data are collected and created, so that data can be integrated and re-used. The next layer includes metadata that describes data sources in a structured way and allows potential data users to find out what data are available. Above that, there is a layer of data models and applications that depend on the data sources and discovery services. This layer, too, requires a degree of standardization, so that the models know what to "expect." A number of organizations such as the ICASA and CIAT work at this level, with agricultural (DSSAT) and biodiversity modeling (Floramap). The lower layers together are the basis of the underlying data infrastructure that supports a host of analyses – such as assessing the effectiveness of in-situ germplasm conversation, modeling land cover impacts, flood forecasting, etc. Typically, as shown in the top layer, research projects and web portals function 'above' the data sources, services, and models. In other words, they rely upon the underlying data infrastructure to provide information, foster interoperability, and convey policies and strategies for better management of resources.

Unfortunately, though, research projects often have limited resources that are devoted entirely to "higher level" activities (modeling and publishing of results). The 'nuts and bolts' of data and standards that support the research often have not been adequately addressed. For this reason, the continuation of GASSIA must focus on the underlying data infrastructure and mechanisms for greater collaboration among geographic information science and technology professionals.

Workshop Results and Actions

1.) Proof of concept: metadata, clearinghouses, Internet map services

The first week of the GASSIA Workshop concentrated on technical training. Participants learned IMS technologies, ISO geographic metadata standard and software, and how to establish a spatial data clearinghouse Internet node for their organizations. The 27 participants often possessed strong GIS capabilities and a commitment to Internet services and applications. They clearly developed a close-knit network and agreed to make significant contributions, illustrating their capabilities and intent on cooperation, in anticipation of the WSSD.

Recommendation/Action 1.1. The GASSIA Workshop participants agreed to start building the infrastructure for distributed GIS in agriculture. The initiative is voluntary, is based on a networking organizational approach, and lets each individual organization decide how they will participate. This activity will provide access to agricultural and other geospatial data for on-line consultation, allowing potential users to overcome a big hurdle: data ownership and knowledge of a GIS software package. An IMS will run software on the computers that store the spatial datasets, allowing users to access the data via a simple Web browser. An IMS-based system offers an exponential step forward for spatial data use by allowing wider access to some of the analytical and visualization tools GIS systems provide, thereby providing access to those who do not necessarily have the software or data themselves. Internet map servers containing agricultural data sets extend the utility of these datasets, since potential users will be able to integrate the data "on the fly" using a web browser, without needing to have the data themselves on their hard drives.

Recommendation/Action 1.2. The first phase of this commitment will result in a multi-institutional demonstration ready by the WSSD. Real-time demonstrations will show how geographic information from multiple map servers can be viewed, queried and analyzed within the same browser. The demonstration will emphasize how the adoption of geographic data standards, OpenGIS protocols, and other SDI concepts can have a multiplier effect, greatly expanding the potential application of geographic information science to sustainable agriculture.

Recommendation/Action 1.3. Each participating center will select a digital data set for Africa that can be incorporated into a "sustainable agriculture use case scenario." Each center will create metadata for its digital maps using the ISO standard in order to join global GIS networks. Participants agreed to prepare their data and set up their IMS to allow Michelle Anthony to conduct a multiviewer demonstration at the WSSD.

Recommendation/Action 1.4. Each center will register its organization as a geographic clearinghouse node using the Z39.50 protocol for Internet communication. This protocol allows any Internet user to search the geographic metadata of any node on the network. Users can find out if a data set fits their analysis needs and how to acquire the data. Metadata and clearinghouse nodes are key elements of spatial data infrastructure that provide a platform for better management of geographic data within the international agricultural research and development community.

Recommendation/Action 1.5. The GASSIA participants will set up IMS to permit Internet users to browse the map data. The IMS installations will use Open GIS protocols that allow interoperability between different data formats and vendor systems. The participants requested that Michelle Anthony be available to provide technical assistance as each participating organization implements these actions. The budget requirements for this were evaluated and funds to secure her technical support prior to the WSSD were obtained.

Recommendation/Action 1.6. Future developments will include the addition of information from past GIS projects, and all new GIS projects are expected to have distributed GIS components as an integral part of their overall implementation. Efforts will be made to "web-enable" past projects such as the commodity atlases that the CGIAR did before GIS. The CGIAR centers have decades of knowledge and information that so far has been under-used and is sitting on shelves, tapes and floppies. Most crop improvement centers have up to thousands of plot years of experimental data with performance and yield information that could be useful to farmers in similar environments.

Recommendation/Action 1.7. Convey an urgent request to organization administrators that the greatest limitation for effective implementation is the allocation of funds to provide time for what is viewed as a valuable activity that supports all projects and most centers' missions. When asked in a GASSIA training workshop evaluation questionnaire about the constraints for developing the technical components for distributed GIS in agriculture, the participants identified funding as their most significant constraint, then staffing and time. In effect, the technical limitations such as having adequate servers, Internet connectivity, or IT administration support, are not seen as inhibiting factors as much as the institutional challenge of being able to devote staff to the task.

Recommendation/Action 1.8. Participants recommended that a follow-up technical workshop be organized in 12 months. The agenda and mechanism need to be developed jointly but should include an update to the clearinghouse and map serving activity to rectify technical or system problems and to maintain the network of peers that was established by GASSIA.

Recommendation/Action 1.9. An email listserver and a website (virtual café) were established during the workshop and will be continued to announce new solutions, advances, and updates as well as share the progress of each organization.

Recommendation/Action 1.10. USGS/EDC will provide technical support through the completion of the proof of concept activity.

2.) Core data and data standards needs

Recommendation/Action 2.1. The international agricultural research community needs to elaborate a data development research work plan that incorporates time and resources for the development of critical data, standards for data quality, data documentation, and mechanisms for exchange of geographic information. This work plan should be developed with input from various organizations, including international research centers, national research and development organizations, private and public input, and other organizations with vested interests.

Recommendation/Action 2.2. The workshop organizers shall identify and establish a task force to categorize and evaluate the key thematic data sets needed, identify the gaps in geographic and temporal data coverage, and specify the regions to be given high priority for data development due to pressing agricultural and environmental problems. Agricultural and environmental scientists commonly deal with climate surfaces, soil maps, hydrographical data, digital elevation models, remote sensing and socioeconomic data. For each of these thematic areas, a situation report is needed to better define data gaps. The situation reports could then be used to establish programs to develop a data model for international agricultural research.

Recommendation/Action 2.3. The international agricultural research community needs guidelines for GIS data quality, data documentation or metadata standards, thematic data classification standards and coding norms for attribute data. There needs to be a definition of minimum data requirements at the household, watershed, national and regional scales to accomplish key research and development goals. The process to develop these guidelines and requirements could build on similar work done by ICASA (http://www.icasanet.org) in defining a set of standards for storing and exchanging data worldwide for crop modeling and agricultural systems applications. Adoption of standards for GIS in international agriculture should build on existing efforts such as those of ICASA, ISO, and national efforts of the most advanced countries in the development of spatial data infrastructures. The initiative can save time and avoid duplication of effort by capturing the progress already made.

Recommendation/Action 2.4. The group strongly endorses the "proof of concept" effort and requests each participating organization to establish a data distribution architecture following international standards so that they can "participate" in established, distributed, standards-based networks. Each organization participating in the network will have the responsibility to maintain its data and the metadata describing its content.

Recommendation/Action 2.5. The group recognizes that AEGIS and similar cooperative activities will require a distributed system of data servers and recommends a search mechanism that facilitates the agricultural community and the CSI. Scientists, analysts, and other users would go to a website where they can use searching tools designed specifically for the international agriculture and environment community. The search mechanism would communicate with network nodes based on the OGC-compliant Z39.50 standard. Since structured metadata on the spatial data clearinghouse nodes holds keyword information, users can search for data according to a specified geographic area, a theme keyword, a place name, a temporal range and other criteria.

3.) Capacity building targets

This section discusses the human resource capacities needed to have effective data distribution networks to support sustainable development and agricultural research. Users of geographic information and spatial analysis tools must drive efforts to advance GIS in international agriculture. The short-term challenge is to focus on users and applications. In many developing countries, the infrastructure for using and communicating geographic information is limited. Many agricultural scientists and analysts are unaware of the utility of geographical analysis and spatial thinking. Progress is hindered by the lack of a critical mass of specialists. Resolving these problems will require a long-term investment in capacity building.

Recommendation/Action 3.1. The development of global networks for sharing geographic information and tools must be inclusive and take into account the needs and demands of farmers, local communities, extension agents, NARS, advanced research institutes and international donors. Successful capacity building in geographic information science requires an answer to the question, "Who are our users?" Poor developing-country farmers are not going to be using GPS or variable rate application technologies. However, they are already precision agriculture specialists, since they know their small farms better than most large land-area farmers know theirs. Our most important users include the local MAG extension agent, the technicians and analysts at the MAG national headquarters, and the research and development communities including the IARCs, NGOs, universities, etc. GIS professionals working in international agriculture must specify what information is needed and how it flows between this group of stakeholders. They need to identify the physical and human resources limitations to information flow. These analyses will determine who would benefit from training and what investments have the best chance to produce sustainable change. Potential winners and users of improved information flow must be identified. To facilitate this recommendation the group proposes that a capacity building strategy be advanced by the following short-term actions:

Recommendation/Action 3.2. Appoint a working group to identify specific needs and gaps in information flow. The working group should develop an assessment that can build on existing studies in the information and communication technologies literature.

Recommendation/Action 3.3. Demonstrate the utility of geographic information and ICT through case studies and spatial awareness packages that show the potential applications to users. The target group should be specific users as well a broad range of users who may not be traditional stakeholders. Case studies and spatial awareness packages such as http://www.povertymap.net, the GIS in Agricultural Research Awareness Package (http://www.grida.no/cgiar/htmls/-awpack.htm), and the Africa Data Dissemination Service (http://edcintl.cr.usgs.gov/adds-/adds.html) are three examples of the types of initiatives that demonstrate the utility of geographic information science.

Recommendation/Action 3.4. Develop synergy between the spatial information community and the agricultural systems applications community represented by ICASA. For example, recent work by CGIAR scientists to generate climate data for crop models and to develop spatially explicit crop models shows the benefits to both communities.

Recommendation/Action 3.5. The GASSIA workshop report should be shared with donors and others interested in capacity building. Within the proper framework, increased capacities of providers and users of geographic information will be crucial for making the most of new opportunities to develop geospatial applications for international agriculture. Include the assessment of capacity-building requirements in forthcoming donor consultations on information dissemination for agricultural development. For example, GASSIA Workshop participants could send recommendations to the U.S. National Academy of Sciences for inclusion in their study on research and development needs in international agriculture. The next section of this report discusses how the international agricultural development community, including both data providers and users, can work within an organizational framework to apply geographic information science and technology for sustainable agriculture.

4.) Framework for future collaboration

Advancing the use of GIS data and tools in international agriculture will require the development of a framework and organizational approach to make it happen. The formation of CSI was a major mechanism by which the CGIAR could advance their shared resources and expertise to meet common problems. It is now clear that the technological advances now allow a fully functional collaboration with distributed peer cooperators and the opportunity to more fully incorporate the national and regional organizations. The question now is how to sustain such an initiative and incorporate or cooperate with these partners and other international centers and organizations.

Recommendation/Action 4.1. A framework is needed to address the unique issues related to geographic information and sustainable agriculture. Over 20 global SDI initiatives have been formed, including Digital Earth, the Global Disaster Information Network and the Global Land Cover Network. More than 45 countries are developing NSDI. Fifteen regional SDI initiatives are in place. Since none of these initiatives focuses exclusively on agriculture in developing countries and often are not concerned with the development of applications or tools for sustainable applications in agriculture, this should be a key component in the framework. The framework should build on existing initiatives with proven records and commitments to sustainable capacity building such as the CGIAR’s CSI, USGS’s FEWS NET, and the Open GIS Consortium.

Recommendation/Action 4.2. The framework for geographic information science and technology development in international agriculture should be based on a networking organizational approach. This approach was defined in some detail by a GASSIA Workshop working paper that proposed the development of AEGIS or "GIS Backbone" for sustainable agriculture (http://edcintl.cr.usgs.gov/gassia.html). The paper elaborates by saying:

> *The exact institutional or technical makeup of the "GIS Backbone" is yet to be defined. This is because like the Internet itself, the potential implementing partners, users and providers are "distributed" into complex networks and institutional relationships… [Collaborating organizations] have differing approaches to sharing and producing data and working with partners, varying funding patterns and relationships, and reflect differing constituencies, eg. Universities, NGOs, foundations, multilateral agencies, national governments, IARCs, NARC, and industry.*

The paper stresses the need to support individual organizations to develop their own part of the international spatial data infrastructure for natural resource management, planning, and agriculture, emphasizing that this initiative "must be seen as a long-term vision that will take 10-15 years to achieve – not a specific project."

Recommendation/Action 4.3. A wide range of organizations will participate in the implementation of AEGIS within a distributed networking organizational structure. This implies a high level of inclusion and cooperation. It also assures that proprietary interests are maintained, that data ownership remains clear, that the responsibility for data maintenance rests clearly defined data guardians, and that organized development occurs. The AEGIS concept is already developing its own momentum through the participants in the GASSIA Workshop and others interested in geographic information and GIS tools for international agriculture. A workshop which was initially intended to meet the immediate needs of the CGIAR and EDC soon became inclusive of many research and development organizations representing many sectors, donors, and countries. No single institution will dominate the initiative.

Recommendation/Action 4.4. The purpose of the network will be to promote the development and use of spatial databases, tools, and applications for various purposes but certainly to include agriculture and natural resources in the context of sustainable development. Network participants could include the IARCs, government organizations, universities, NGOs, the private sector and others. The benefits of participation would include access to and sharing of expertise, exchange of information on data, tools and applications, and increased awareness of opportunities for and the value of spatial analysis in sustainable development.

Recommendation/Action 4.5. Network activities should be initiated immediately to maintain interest and momentum and should plan for an annual meeting, a web site and Internet forum, and mechanisms for joint action with donors, vendors and others. The network could also be a potential source for endorsement and development of initiatives, standards and common efforts.

Recommendation/Action 4.6. The GASSIA working group on organizational structures proposes that the Directors General of the CGIAR centers and other participating organizations be informed of the recommendations from GASSIA including the steps to approach an AEGIS. The participating organizations could be asked for some form of endorsement for the proposed initiative.

Recommendation/Action 4.7. A task force or steering committee should be formed to plan the next steps for facilitating the organizational framework. While the framework for collaboration builds on networking approaches, concrete steps need to be taken by individuals, government agencies, international research institutions, and others. The workshop organizers are asked to implement these continued actions.

5.) Recommendations for donors and the wider agricultural development community

The GASSIA Workshop participants formed a working group to make recommendations to donor communities and the broad range of stakeholders. These suggestions are in response to an understanding of the central role that donors, and recipient countries, can play in assuring that certain acceptable practices are maintained and endorsed. In fact these practices could become a condition or expectation of award as is, for example, the publication of results in peer-reviewed journals. The suggestions also reflect the need in many donor projects for the development and application of geospatial data, a need which by itself endorses the value of those activities. The values of those activities, however, are diminished when the data are not generally available to other users or are produced in a format and with standards that are not easily compatible or interoperable. It is a simple requirement that all projects should be asked to meet, and the donors are in a position to make this happen. The donors also have a responsibility to see that some level of georeferenced project location be identified and made available for spatial searching. This could mean a simple Clearinghouse node maintained by a donor server and meeting international standards.

Recommendation/Action 5.1. Donors should make more explicit efforts to apply geospatial tools for international development. In particular, they should revisit the CGIAR Science Council's "Strong Report," which highlights the importance of these tools. The workshop organizers should continue to inform the donor and development communities about the importance of geospatial technologies as an integrating mechanism for the wide variety of thematic areas, in particular the CGIAR challenge programs. This integration also implies an efficiency of services and will lead to greater inter-project collaboration.

Recommendation/Action 5.2. A comprehensive needs assessment for core data should be carried out for the major developing world regions and at regional and national levels. Core data for agriculture includes climate, weather, land cover, soils, demographic, agricultural statistics, and other data upon which a wide range of spatial analyses are performed.

Recommendation/Action 5.3. There should be an emphasis on supporting core data production and an implementation plan to attain this could be identified as a priority activity for GASSIA continuation. This support would be analogous to funding basic science but is likely of even greater long-term value, when done correctly, than scientific publications.

Recommendation/Action 5.4. The international agricultural development community should encourage improved Internet access in developing countries. This needs to support the flow of information between individuals, government ministries, NGOs, universities, advanced research institutes, IARCs and other organizations supporting sustainable agriculture. Although substantial progress has been made in this area with donor support, efforts need to be continued to encourage competition in the provision of these resources; and the donors are better positioned than anyone to provide incentives.

Recommendation/Action 5.5. Project investments should be implemented within policies that emphasize data standards, best practices, data accessibility, and incorporation of OpenGIS protocols. Projects should build in data protocols in the initial funding arrangements.

Recommendation/Action 5.6. Donors should require recipients to deposit their data with full metadata in a clearinghouse or other accessible location. This would be a condition of the award, just as scientific publications for research grants are expected. All donors should consider, as some have, rescuing completed projects at least to the extent of geo-referencing the work described in final reports. All funded projects should be geo-referenced to enable the creation of a database of agricultural and environmental development projects, including geographic information on field sites and areas of influence on each project.

Recommendation/Action 5.7. A task force with multi-donor funding should develop a strategy to evaluate the need for investments to achieve sustainability of national agency geographic information systems and other geospatial facilities. Efforts should be made to increase awareness in the donor community of the difficulty and cost for national agencies to establish and maintain a spatial data facility. Investments that require adherence to standards and interoperability could also help insure the availability of data even in times of insecurity.

Recommendation/Action 5.8. Funding for training, internships, graduate and post-graduate fellowships, and other activities to promote capacity building in developing countries should be increased. This support can be provided in ways that not only support sustainable development, but also directly encourage human networking and common practices on a global network.

Recommendation/Action 5.9. Investments should support innovative applications which are cost effective and apply cutting edge technologies, such as the newly advanced remote sensing tools, hand-held GIS for fieldwork, Internet map services and global positioning systems. These investments and practices should be promoted even though the infrastructure and capacity are not necessarily present today. New developments hold the promise for developing countries to "leap frog" certain technological steps. Thus, the potential for true peer cooperation in the future is maintained and could become a reality.

Conclusion

The GASSIA Workshop evaluated the potential of new information technologies to contribute to development objectives and the requirements for access to relevant geospatial data for sustainable development in developing countries. Although a substantial amount of progress has been made, especially in some countries and some centers, geographic information science for developing country agriculture and planning is far from reaching its potential. Reasons for this are related to inefficient data development and distribution, the absence of reasonable requirements for data standards and disposition in project plans, the lack of accepted standards, and inadequate capacity and infrastructure. The diverse representatives at the workshop firmly endorsed the potential value for developing an alliance in support of an AEGIS framework.

The GASSIA Workshop provided insights to chart the next steps for capturing the benefits of geographic information science and technology for sustainable development. An improved data infrastructure will enable partners to make more-informed decisions based on knowledge-rich maps and charts underpinned by component inputs of climate, biology, genetics, pests, and market dynamics. Building infrastructure is not a trivial undertaking, and cannot be solved by technology alone. The most crucial elements are institutional awareness, consensus, and cooperation. Developing the backbone of AEGIS will require long-term commitment. However, it can be implemented in phases, each with clear products, timetables, and responsibilities. The technologies already exist, and the proof-of-concept initiative that developed out of the GASSIA Workshop demonstrates that the workshop participants are already eager to cultivate a collaborative research environment that transcends any one center – a global alliance for sustainable development.

References

Kelmelis, J., 2001. Spatial Data Infrastructures: the advantage of International Standards. Presentation at the Plenary of the Pan American Institute for Geography and History, Bogota, Colombia, October 2001.

Appendix A. GASSIA Workshop participants

André Nonguierma	AGRHYMET
Amadou Moctar Dieye	CSE
Glenn Hyman	CIAT
Elizabeth Barona	CIAT
Simon Cook	CIAT
Atie Puntodewo	CIFOR
Jeff White	CIMMYT
Paul Uhlir	The National Academies
Chris Lenhardt	Columbia University - CIESIN
Nick Thomas	ESRI
Ryan Budlong	ESRI
Mark Ho	ESRI
Hugo Ahlenius	GRID-ARENDAL
Eddy De Pauw	ICARDA
Adekunle G. Ibiyemi	ICARDA
Robert Zomer	ICRAF
Pornwilai Saipothong	ICRAF
Pierre Sibiry Traore	ICRISAT
Roger Longhorn	IDG (UK) Ltd
Carl J. Neidert	IFDC
Paul Wilkens	IFDC
Stanley Wood	IFPRI
Jordan Chamberlin	IFPRI
Bauke van der Meer	IITA
Russ Kruska	ILRI
Tineke de Wolff	ILRI
Tom Crawford	INTSORMIL
Abdoubarri Dicko	INSAH
Santiago Borrero	Instituto Agustin Codazzi and GSDI
Suan Pheng Kam	IRRI
Nestor Fabellar	IRRI
David Bigman	ISNAR
Victoria Henson-Apollonio	ISNAR
Wolfgang Flügel	IWMI
Randy Jeske	Mud Springs Geographers
John Corbett	Mud Springs Geographers
Laila Aslesen	Norwegian Mapping Authority
Sam Bacharach	Open GIS Consortium
Carlos Perez	SANREM CRSP/University of Georgia
Andrew Stancioff	Stone Environmental Inc.
Sherree Westell	Taylor Joynson Garrett
George Cho	University of Canberra
William Bell	University of Georgia
Nancy Kingsbury	US Department of State - Humanitarian Information Unit
Dennis King	US Department of State - Humanitarian Information Unit
Meredith Soule	USAID
Robert Ford	USAID
Susan Thompson	USAID
Larry Tieszen	USGS/EROS Data Center
Kate Lance	USGS & GSDI
Eric van Praag	USGS/EROS Data Center
Martin Ruzek	USRA

Appendix B. Presentations and Presenters

Presentation Topic	Presenter	Organization
IPR and Legal Issues	Victoria Henson-Apollonio	CGIAR-CAS
Poverty Mapping Initiative	Glenn Hyman	CIAT
CSI Overview	Glenn Hyman	CIAT
IPR and Legal Issues	Jeff White	CIMMYT
Overview of CIESIN Projects	Chris Lenhardt	Columbia University
CSE	Amadou Dieye	CSE
GNET	Nick Thomas	ESRI
Public/Private Sector Development	Santiago Borrero	GSDI
GSDI – Progress and Future Plans	Santiago Borrero	GSDI
Information Sharing in Complex Emergencies—U.S. Department of State	Dennis King	Humanitarian Information Unit
IP Issues for Spatial Data	Roger Longhorn	IDG (UK) Ltd
Other Legal Issues for Spatial Data	Roger Longhorn	IDG (UK) Ltd
IP Issues for Software	Roger Longhorn	IDG (UK) Ltd
Public vs Private Sector Development	Roger Longhorn	IDG (UK) Ltd
Scenario FUDs	Roger Longhorn	IDG (UK) Ltd
INSPIRE	Roger Longhorn	IDG (UK) Ltd
Overview of IFDC	Paul Wilkens and Carl Neidert	IFDC
IFPRI	Stanley Wood	IFPRI
AWhereACT	John Corbett	Mud Springs Geographers, Inc.
Data Access Policy	Laila Aslesen	Norwegian Mapping Authority
Open GIS Consortium	Sam Bacharach	OGC
CRSP	Carlos Perez	SANREM CRSP
Preliminary Atlas of Poverty Vulnerability	Andrew Stancioff	Stone Consulting, Inc.
Data Licensing	Sherree Westell	Taylor Joynson Garrett
UNEP.Net	Michelle Anthony and Ashbindu Singh	UNEP
Licensing and Liability IP Software	George Cho	University of Canberra
UNGIST	William Bell	University of Georgia
Future Directions for Agriculture	Meredith Soule	USAID
Future Directions for Agriculture	Susan Thompson	USAID
GISD RAISE	Robert Ford	USAID
GISD WSSD	Robert Ford	USAID
FEWS NET	James Verdin	USGS
Overview of USGS International Program	Jim Verdin	USGS
USGS Land Remote Sensing Program	RJ Thompson	USGS
SDI Initiatives in Africa	Kate Lance	USGS & GSDI

Appendix C. Intellectual Property Rights and GIS Seminar Agenda

Tuesday, May 28, 2002:

Time	Topic	Speaker
8:00 a.m.	Welcome	Tom Holm, EDC Acting Chief
8:05 a.m.	CGIAR-CSI Needs/Opportunities	Glenn Hyman
8:15 a.m.	Intellectual Property Rights (IPR) and Legal Issues – Introduction, Goals of the Workshop	Jeff White*, Victoria Henson-Apollonio*
<u>IP Issues for Spatial Data</u>		
8:25 a.m.	Overview of IP issues for spatial data and Case Study for consideration of issues	Roger Longhorn**
9:00 a.m.	FUD Test: Part 1 and initial questions on issues	
9:20 a.m.	Comments on IP protection for data in a global context	George Cho
9:40 a.m.	Discussion	
10:10 a.m.	**Break**	
<u>Other Legal Issues in Use of Spatial Data: Confidentiality, Licensing and Liability</u>		
10:40 a.m.	Overview of other legal issues for spatial data, Case Study – Spatial Data License Terms & Conditions	Roger Longhorn
11:10 a.m.	FUD Test: Part 2 and initial questions on issues	
11:20 a.m.	Comments on licensing and liability for data	Sherree Westell
11:35 a.m.	Discussion	
12:00 p.m.	**Lunch**	
<u>IP Issues in Creation, Use and Distribution of Software</u>		
1:00 p.m.	Overview of IP issues for software – copyright v. patent Case Study – software license Terms & Conditions	Roger Longhorn
1:25 p.m.	FUD Test: Part 3 and initial questions on issues	
1:45 p.m.	Practical implications of IP software IP issues – Licensing and liability	George Cho Sherree Westell
2:05 p.m.	Discussion and questions	
<u>Public vs. Private Sector Development of Data and Tools</u>		
2:25 p.m.	Introduction to the main issues relating to spatial data	Roger Longhorn
2:45 p.m.	National Mapping Agency data access policy and practices in Europe: an overview	Laila Aslesen
3:00 p.m.	**Break - George McGovern presentation and reception**	
3:30 p.m.	Public-private sector involvement in SDI development	Santiago Borrero
3:45 p.m.	Role of public domain information in research	Paul Uhlir
4:00 p.m.	General discussion – FUD Test Results	Panel of Experts
4:15 p.m.	What is GISD-ICP?	Sam Bacharach
4:30 p.m.	Conclusion, including next steps	CSI representatives
5:00 p.m.	**Close**	Victoria Henson-Apollonio Jeff White

***IPR Workshop Coordinator**
****IPR Workshop Leader**

Appendix D. Agricultural and Environmental Geospatial Information System (AEGIS) Agenda

How can we facilitate the work and interests of international organizations and projects, stimulate and support data sharing and distribution, and provide resources to promote sustainable agriculture and alleviate poverty?

This special event will encompass both days and will be structured around the ideas and plans that are underway to enhance the application of geospatial data for international agriculture R&D and natural resource management.

Wednesday, May 29, 2002:

8:00 a.m.	Presentation of Agenda, Summary of Week 1, and Overview of Objectives	Larry Tieszen, Chair
8:15 a.m.	Future Directions for Agriculture	Susan Thompson
8:30 a.m.	USAID Project Impact Assessment	Stanley Wood
8:45 a.m.	AEGIS (Agricultural and Environmental Geospatial Information System)	Robert Ford
9:10 a.m.	Geospatial Data Delivery and Applications in Developing Countries: Visions for an Agriculture/Natural Resource Management Sub-Network	Nick Thomas
9:30 a.m.	GIST Data Warehouse: Sharing of GIS data for disaster management	Bill Bell
9:45 a.m.	FEWS NET: Case Study of Applications and Data Needs	Jim Verdin
10:00 a.m.	Break	
	Chair	Glenn Hyman
10:20 a.m.	Spatial Data Infrastructure in Developing Countries: Capacity Building and Research Needs	Kate Lance
10:40 a.m.	GSDI: Progress and Future Plans	Santiago Borrero
11:00 a.m.	INfrastructure for SPatial InfoRmation in Europe (INSPIRE)	Roger Longhorn
11:20 a.m.	Humanitarian Information Unit – Geospatial Information for Relief Operations	Dennis King
11:45 a.m.	Lunch	
	Chair	Meredith Soule
12:45 p.m.	How can AEGIS, CSI and others target the poor?	David Bigman
1:00 p.m.	Poverty Targeting and Agricultural Land Use: World Bank Overview	Andrew Stancioff
1:20 p.m.	The CSI/GRID/FAO Poverty Mapping Initiative	Glenn Hyman
1:40 p.m.	Breakout Session	
3:30 p.m.	Reception and Poster Session	
5:30 p.m.	Return to Hotel	

Thursday, May 30, 2002 Agenda:

	Chair	Robert Ford
8:00 a.m.	The Country Almanac Series: A Vision for the Present	John Corbett, Jeff White
8:20 a.m.	UNEP.Net: a Plan for Environmental Information Distribution	Ashbindu Singh
8:40 a.m.	Overview of CRSP Programs and Response to AEGIS	Carlos Perez
9:00 a.m.	Overview of CSI-CGIAR and Response	Glenn Hyman
9:20 a.m.	Overview of EDC International Program and Response	Jim Verdin
9:30 a.m.	Overview of IFDC and Response	Paul Wilkens
9:40 a.m.	Overview of CIESIN and Response	Chris Lenhardt

9:50 a.m.	Brief Responses from Other Organizations:	AGRHYMET, CSE, NCRS, Mudsprings, INSAH, ESSE
10:30 a.m.	Break	
10:40 a.m.	Satellite Resources, present and future	R.J. Thompson and EDC Tour
12:00 p.m.	Lunch	
1:00 p.m.	Instructions and Breakout Session 2	Larry Tieszen
3:00 p.m.	Reports from Breakout Groups	Reporters and Chairs
3:40 p.m.	Instructions for Breakout Session 3 Recommendations, Proposed Plan of Action, Draft Proposals	 Larry Tieszen, Robert Ford, and Glenn Hyman
5:00 p.m.	Presentation of Final Reports	Reporters and Chairs
5:30 p.m.	Adjourn	

Acknowledgements

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GASSIA WORKSHOP

Website:

http://edcintl.cr.usgs.gov/gassia.html